Amendments to the Specification

Please replace the paragraph beginning on page 4, line 10, with the following amended paragraph:

The quantum mechanical properties of a qubit are easily affected by interactions between the qubit and the environment (*e.g.*, other systems). Yet quantum computing requires that the qubit be isolated from such interactions so that the state of the qubit can coherently evolve in accordance with a quantum gate that is applied to the qubit. Despite the requirement for isolation so that the qubit can evolve, universal quantum computing still requires some control over (interaction with) the qubit so that fundamental operations such as qubit initialization, gate application, and qubit state measurement can be effected. This apparent contradiction between the need for isolation and the need for control over the ~~quibt~~ qubit is a direct result of the quantum behavior of qubits.

Please add the following paragraphs to page 12 of the specification immediately after line 11 and just prior to the section entitled "DETAILED DESCRIPTION."

An embodiment of the present invention provides a method for entangling a quantum state of a qubit with a quantum state of a resonant control system. The method for entangling a quantum state comprises tuning a resonant control system, which is capacitively or inductively coupled to the first qubit, to a resonant frequency for a period of time. The resonant frequency corresponds to an energy difference between a first energy level and a second energy level of the qubit. The act of tuning entangles the quantum state of the qubit with the quantum state of the resonant control system.

An embodiment of the present invention provides a method for entangling a quantum state of a qubit with a quantum state of a resonant control system, including a Josephson junction. In such an embodiment, the resonant control system includes a Josephson junction with a bias current source that is connected in series with the Josephson junction. The act of tuning comprises altering the magnitude of the bias current source.

Another embodiment of the present invention provides a method for entangling a quantum state of a qubit, within a plurality of qubits, with a quantum

state of a resonant control system. The method includes tuning a resonant control system, which is capacitively or inductively coupled to the qubit within the plurality of qubits, to a resonant frequency. The resonant frequency corresponds to an energy difference between a first energy level and a second energy level of thes selected qubit within the plurality of qubits.

Please replace the paragraph beginning on page 12, line 14, with the following amended paragraph:

In accordance with the present invention, a circuit for controlling a qubit includes a superconducting qubit having a qubit frequency between approximately 0.8 GHz and 40 GHz and a resonant control system that is characterized by a resonant frequency. This resonant frequency is a function of an effective capacitance of the resonant control system as well as an effective inductance of the resonant control system. Further, at least one of the effective capacitance and the effective inductance is adjustable so that the resonant frequency of the resonant control system can be tuned to a predetermined resonant frequency. The circuit further includes a superconducting mechanism coherently coupled to the ~~supreconducting~~ <u>superconducting</u> qubit and the resonant control system. The superconducting mechanism is used to coherently couple the superconducting qubit and the resonant control system together. In some embodiments, the resonant control system is superconducting.

Please replace the paragraph beginning on page 19, line 13, with the following amended paragraph:

In an embodiment of the present invention, the ~~supeconducting~~ <u>superconducting</u> qubit can evolve quantum mechanically when it is coupled to the resonant control system. Further, the state of the superconducting qubit can remain fixed when the resonant control system is not coupled to the superconducting qubit.

Please replace the paragraph beginning on page 20, line 14, with the following amended paragraph:

Some embodiments of the present invention further provide for entangling the states of a first superconducting qubit and a second superconducting qubit in a quantum register by coupling the resonant control system to the first superconducting qubit for a duration t_3. The third entanglement removes entanglement of the tunable resonant control system with the superconducting qubits in the entanglement operation. This ~~entanglemnt~~ entanglement operation implements a square root of SWAP logical operation, which is sufficient, along with single qubit operations, to perform quantum computing. For more details on SWAP operations, see Blais, 2001, Physical Review A 64, 022312, which is hereby incorporated by reference in its entirety.

Please replace the paragraph beginning on page 24, line 10, with the following amended paragraph:

Figure 5B illustrates the potential energy profile for the Josephson junction in a resonant control system that is biased with a current of $0.992*I_c$ or less. In fact, the resonant control system profiled in Figure 5B is the same as the resonant control system profiled in Figure 5A. However, it is clear that the potential energy profile of Figure 5B is not the same as the potential energy profile Figure 5A. In particular, the potential energy profile in Figure 5B has a deeper well. Thus, there are more energy levels in Figure 5B than in Figure 5A. The deeper potential energy well found in Figure 5B is achieved by using a lower biasing current ~~[about~~ (about $0.994*I_c$ or less ~~(Figure 5A)~~ in Figure 5A as opposed to about $0.992*I_c$ or less ~~(Figure 5B)]~~ in Figure 5B). In Figure 5B, the lowest energy levels are isolated at the bottom of a deep potential energy well. A system with the potential energy profile illustrated in Figure 5B functions as a resonant control circuit because the probability of transition to the voltage state, which occurs when the phase escapes the potential energy well, is low.

Please replace the paragraph beginning on page 27, line 6, with the following amended paragraph:

Readout device 650 includes junction 653, a current source 651, a ground 652, and a voltmeter 654. Junction 653 plays the role of changing the behavior of qubit 610 to the nonhysteretic, overdamped mode. In some less preferred embodiments, junction 653 is a shunt resistor made of normal metal. In other embodiments junction 653 is a Josephson

junction with a large normal conductance and small ~~resistance~~ resistance. Methods for providing current source 651 are well known in the art. Current source 651 can be controlled from room temperature equipment using appropriate low-temperature filters. Methods for providing voltmeter 654 are well known in the art. In some embodiments of the invention, the leads connecting to voltmeter 654 can pass through a cold amplifier to be sampled at room temperature.

Please replace the paragraph beginning on page 28, line 16, with the following amended paragraph:

Figure 7 illustrates resonant control system 920 that is in electrical communication with bus 990. In some embodiments resonant control system 920 (Fig. 7) is identical to resonant control system 620 (Fig. 6). As illustrated in Fig. ~~7.~~ 7, resonant control system 920 includes current source 921-1, Josephson junction 921-2, shunt capacitance 921-3, and ground 930_q.

Please replace the paragraph beginning on page 29, line 1, with the following amended paragraph:

The structure of a device 700 which includes a resonant control system 920 has been disclosed (Fig. 7). The structure includes an array (*e.g.*, register, quantum register) of two or more qubits 610. At least two of the qubits 610 in the register are capacitively coupled to resonant control system 920. A method for using device 700 to entangle qubits ~~620~~ 610 will now be described.

Please replace the paragraph beginning on page 31, line 20, with the following amended paragraph:

In Figure 8, quantum register ~~900~~ 800 has qubit groups 802-1 and 802-2. Qubit group 802-1 includes qubits 610-1 and 610-2, resonant control system 920-1, and bus segment 990-1. Qubit group 802-2 includes qubits 610-3 and 610-4, resonant control system 920-2, and bus segment 990-2. Qubits 610-1 through 610-4 are respectively associated with devices 660-1 through 660-4. Each device 660 is a mechanism for

controlling the quantum state of the corresponding qubit 610. In some embodiments, each device 660 controls the quantum state of the corresponding qubit 610 by providing a gate voltage or a microwave signal. For example, in one embodiment, each device 660 includes an A/C current generator 661, a charge device 662, and a ground 630_c as illustrated in Figure 7. In an embodiment of the present invention, at least one qubit 610 in Figure 8 is a superconducting charge qubit and at least one resonant control system 920 in Figure 8 is a resonant control system 620 ~~(Fig. 7)~~ (Fig. 6).

Please replace the paragraph beginning on page 42, line 30, with the following amended paragraph:

In some embodiments, the resonant control circuit is characterized by an inductance and a capacitance. In some instances, the inductance is tunable. In some embodiments, the resonant control circuit comprises a current-biased Josephson junction and the first tuning and the second tuning comprises changing a current bias across the current-biased Josephson junction. Very little change in the current-bias is required. For example, in some embodiments, the current-biased Josephson junction is changed by 1 micro-Ampere or less during the first or second tuning. In another example, the current-biased Josephson junction is changed by ~~by~~ 100 nanoAmperes or less during the first or second tuning.

Please replace the abstract beginning on page 60 with the following replacement abstract:

A method is provided for entangling a quantum state of a qubit with a quantum state of a resonant control system. The method comprises tuning the resonant control system, which is capacitively or inductively coupled to the qubit, to a resonant frequency for a period of time. The resonant frequency corresponds to an energy difference between a first energy level of the qubit and a second energy level of the qubit. The act of tuning entangles the quantum state of the qubit with the quantum state of the resonant control system. A representative resonant control system includes a Josephson junction. A method is also provided for entangling a quantum state of a qubit, within a plurality of qubits, with a quantum state of a resonant control system.